

# Collective Effect Study in 510GeV pp in Run16 with High Multiplicity Event

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for the FVTX trigger team

# Game Change: the “ridge” in pp collisions

## Opportunity of studying novel QCD phenomena opened up by the LHC

September, 2010



PUBLISHED FOR SISSA BY SPRINGER

RECEIVED: September 22, 2010

ACCEPTED: September 23, 2010

PUBLISHED: September 27, 2010

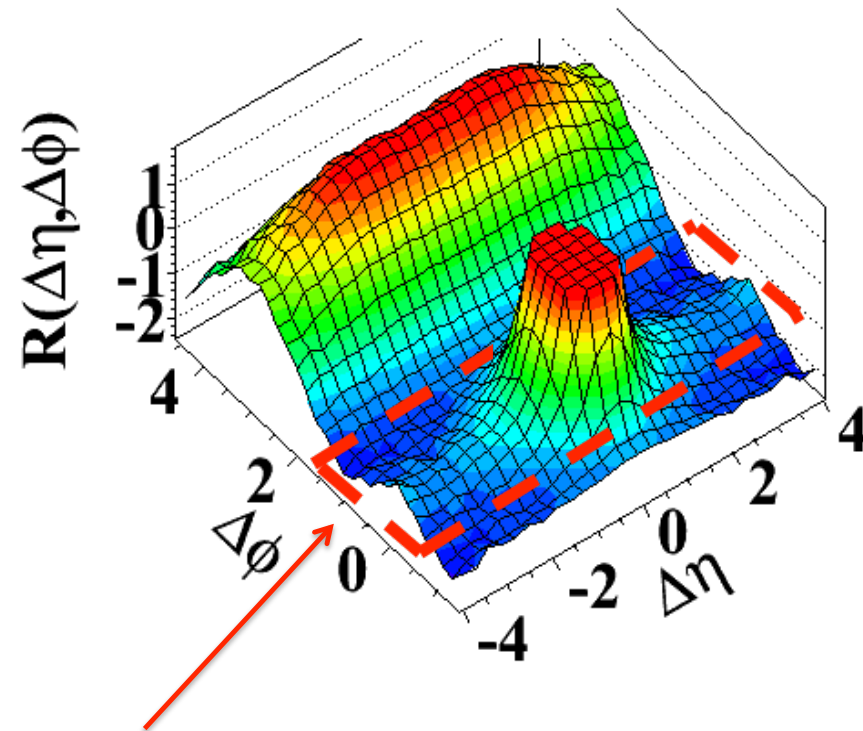
### Observation of long-range, near-side angular correlations in proton-proton collisions at the LHC

The CMS collaboration

ABSTRACT: Results on two-particle angular correlations for charged particles emitted in proton-proton collisions at center-of-mass energies of 0.9, 2.36, and 7 TeV are presented, using data collected with the CMS detector over a broad range of pseudorapidity ( $\eta$ ) and azimuthal angle ( $\phi$ ). Short-range correlations in  $\Delta\eta$ , which are studied in minimum bias

Two-particle  $\Delta\eta$ - $\Delta\phi$  correlation

pp  $N > 110$ ,  $1 < p_T < 3$  GeV/c

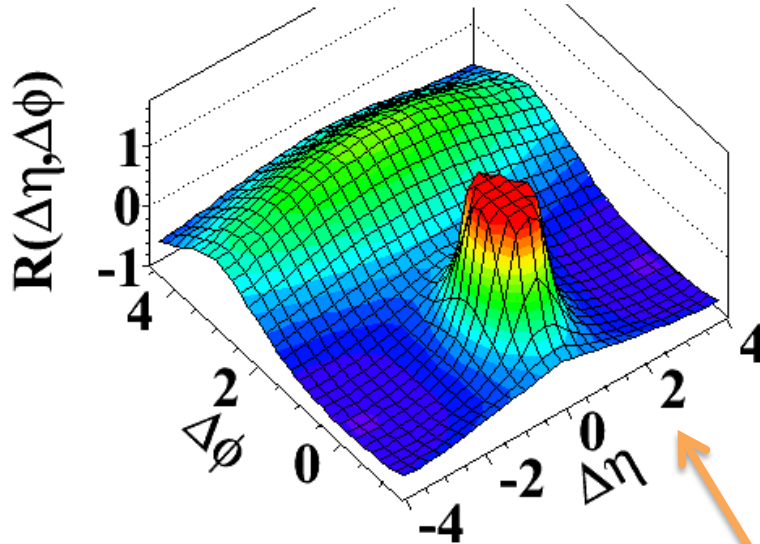


**Unexpected ridge-like correlations in high multiplicity pp!**

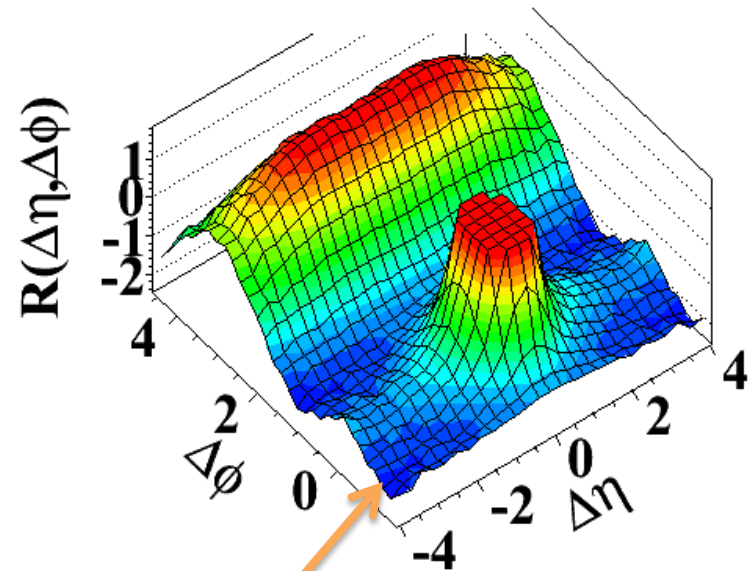
# High Multiplicity Events is the key!

Two-particle  $\Delta\eta$ - $\Delta\phi$  correlation

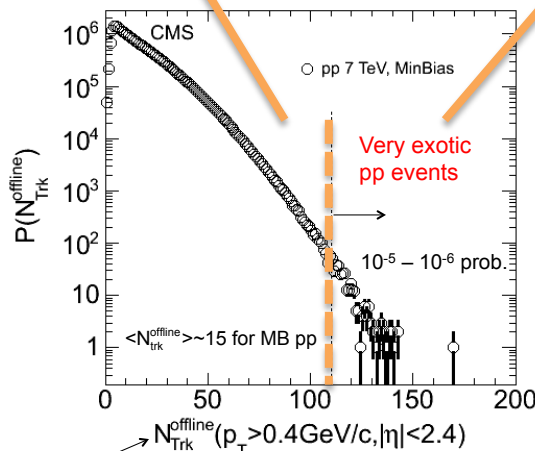
pp  $\langle N \rangle \sim 15$ ,  $1 < p_T < 3$  GeV/c



pp  $N > 110$ ,  $1 < p_T < 3$  GeV/c



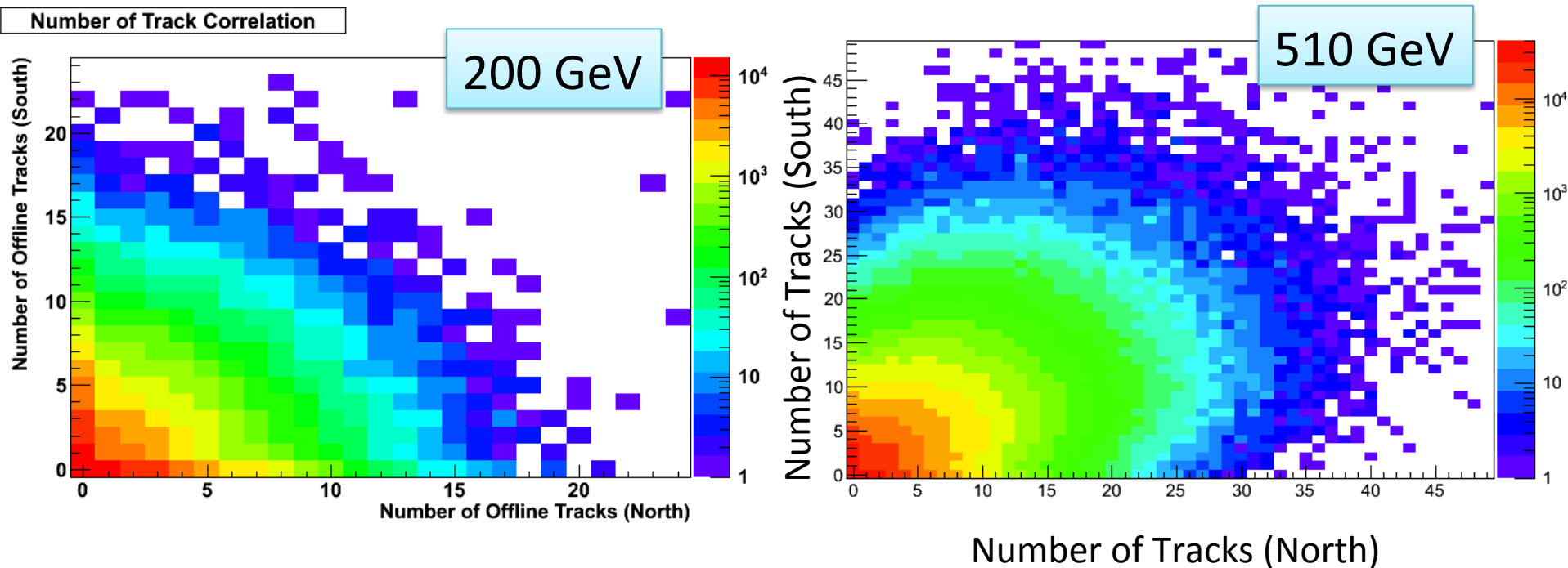
Very high-multiplicity pp events are rare in nature



**110 tracks translated to be  
20~30 tracks/arm in FVTX  
acceptance.**

Raw counts of tracks!

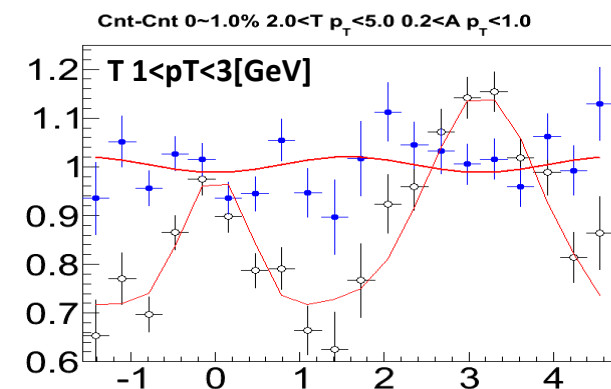
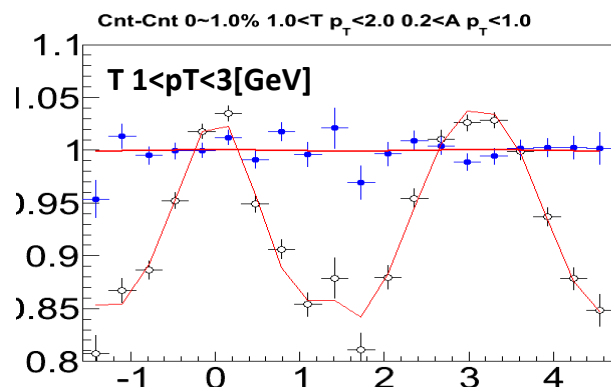
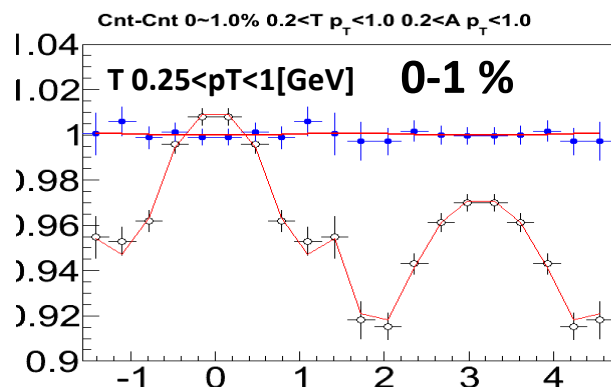
# Wide Rapidity Range Correlation



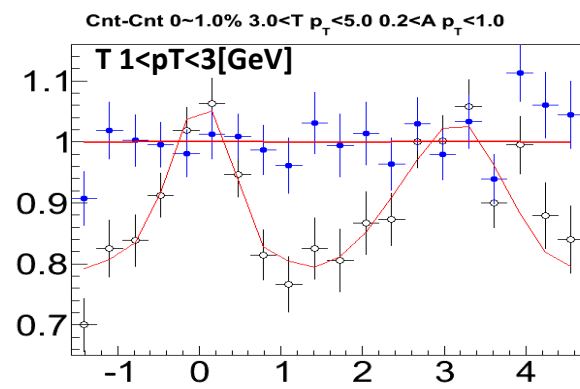
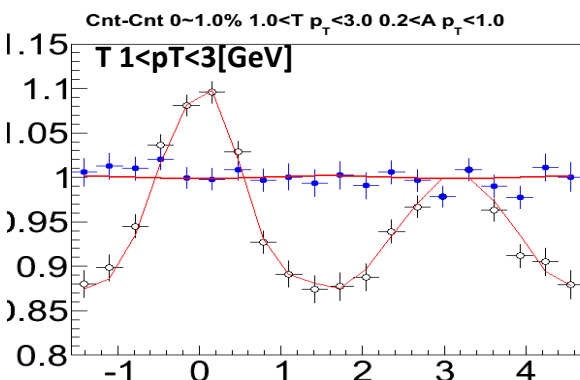
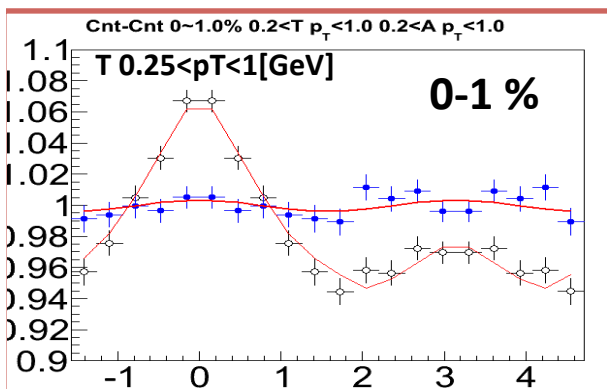
Although North and South (wide rapidity gap) correlation between high multiplicity events is known to be weak to start with though, 510 GeV shows rather stronger correlation compared that of 200 GeV.

# Hiroshi's Run9,13 Study

## pp 200 GeV ERT Cnt-Cnt

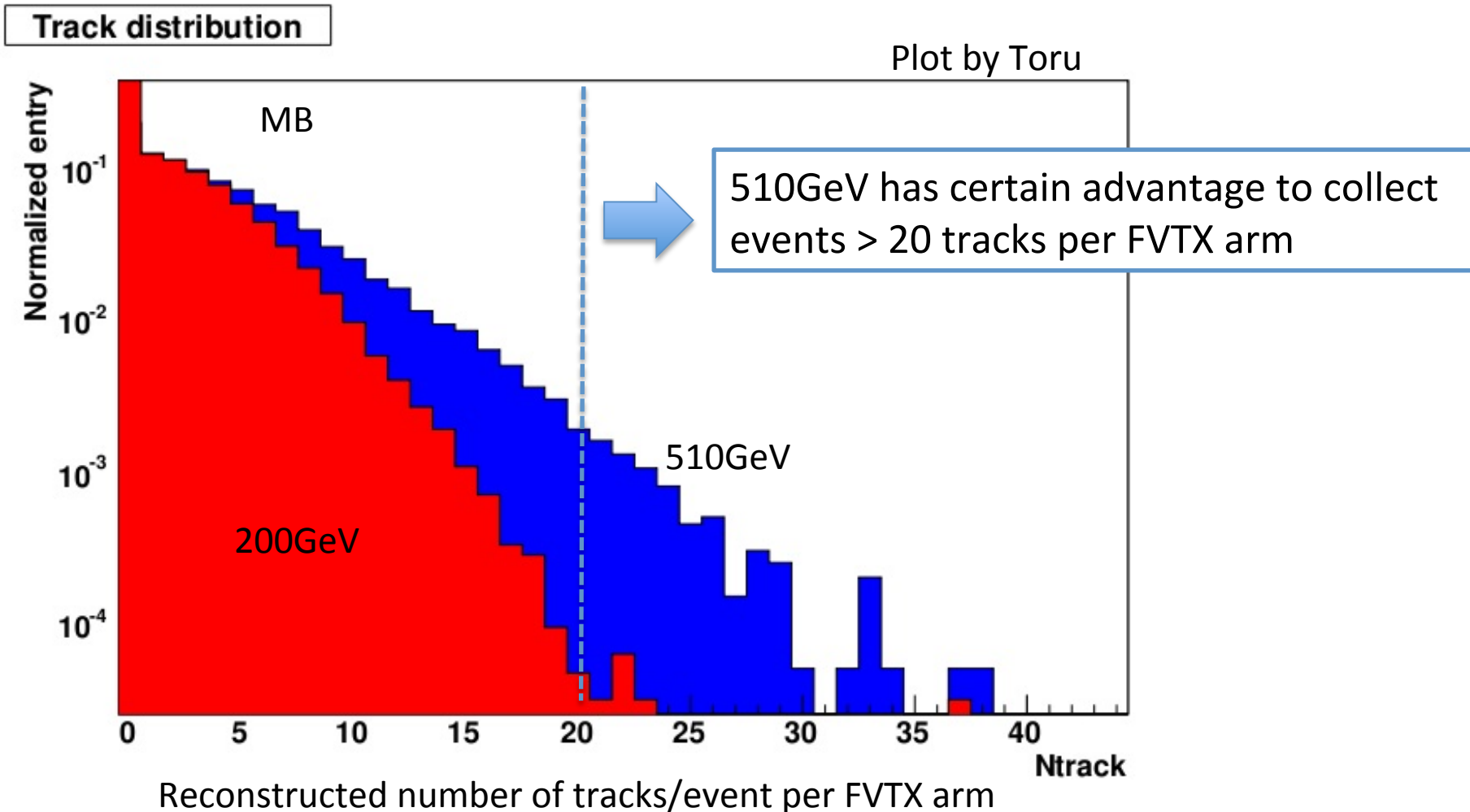


## pp 500 GeV ERT Cnt-Cnt



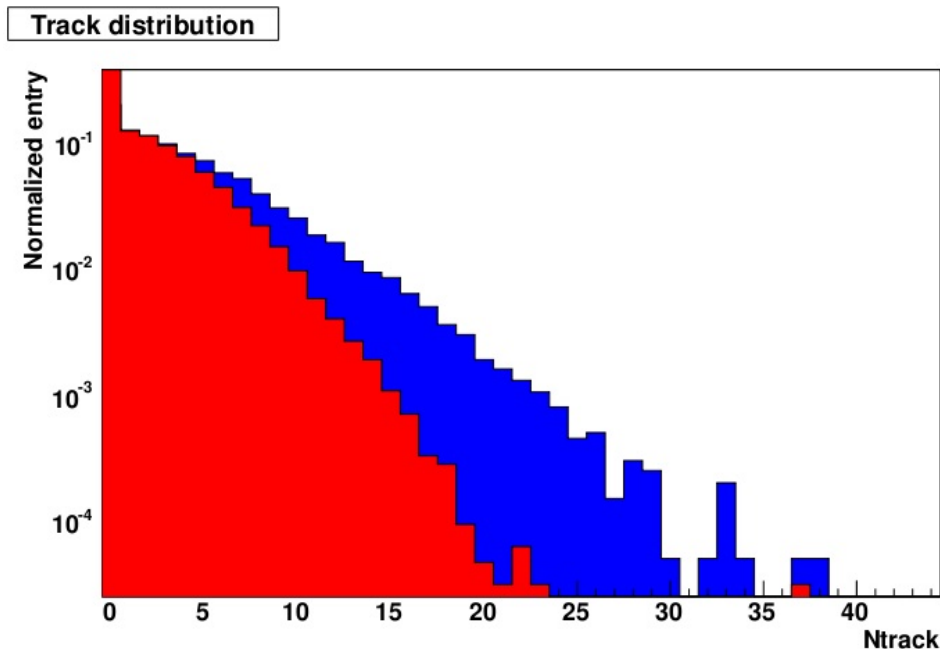
May be some indication of c2 in 500GeV, but need more statistics to be conclusive

# FVTX charged track distribution 200GeV vs. 500GeV



# Fraction of High Multiplicity Events

# of Tracks / arm	> 10	> 20	> 30	> 40
500 GeV	10%	0.7%	0.04%	0.008%
200 GeV	4.1%	0.03%	0.0005%	



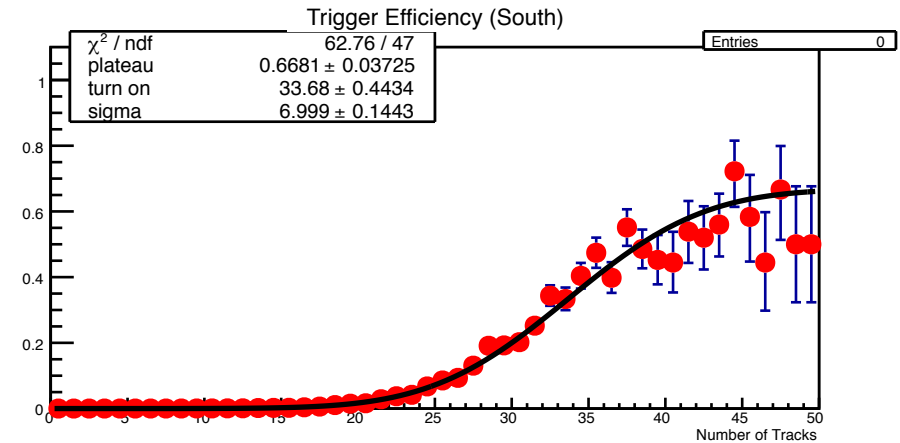
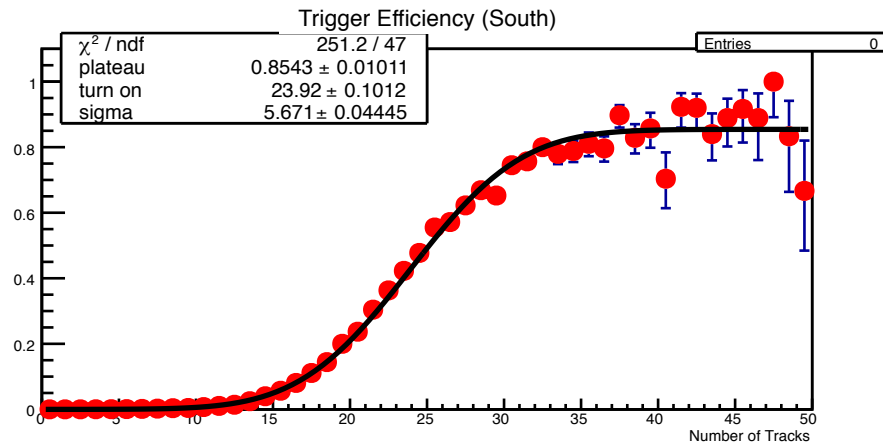
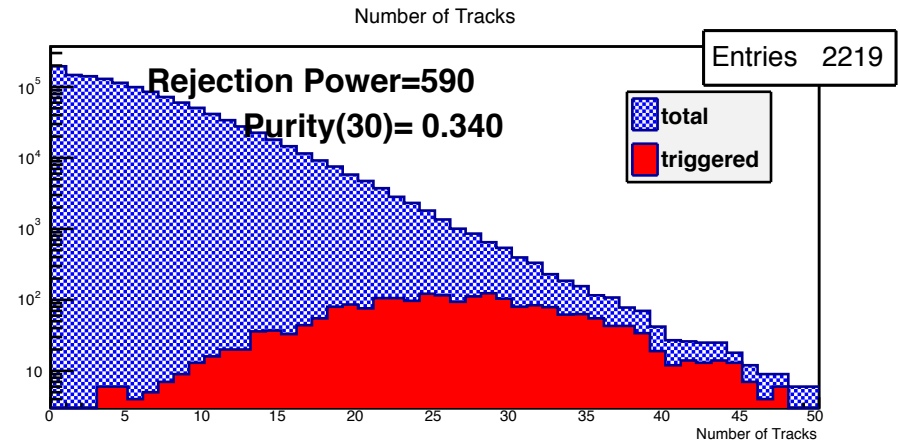
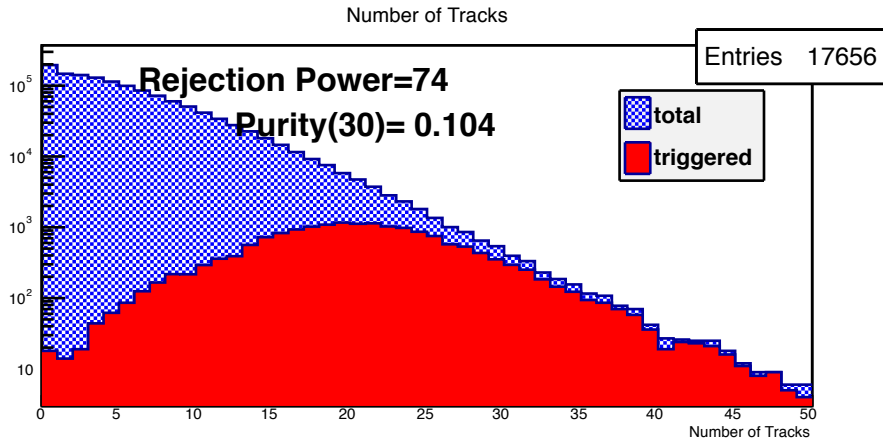
# Required Rejection Power

# of Tracks / arm	> 0	> 10	> 20	> 30	> 40
Fraction in MB	100%	10%	0.7%	0.04%	0.008%
Rates in MB	4MHz	400kHz	28kHz	1.6kHz	320Hz
Required Rejection Power	1	10	142	2,500	12,500

- The maximum luminosity in Run13 was around 3~4MHz.  
-> Expected to be provided x2 => 6~8MHz in Run16.



# FVTX Trigger Performance



# of track  $\geq 14$

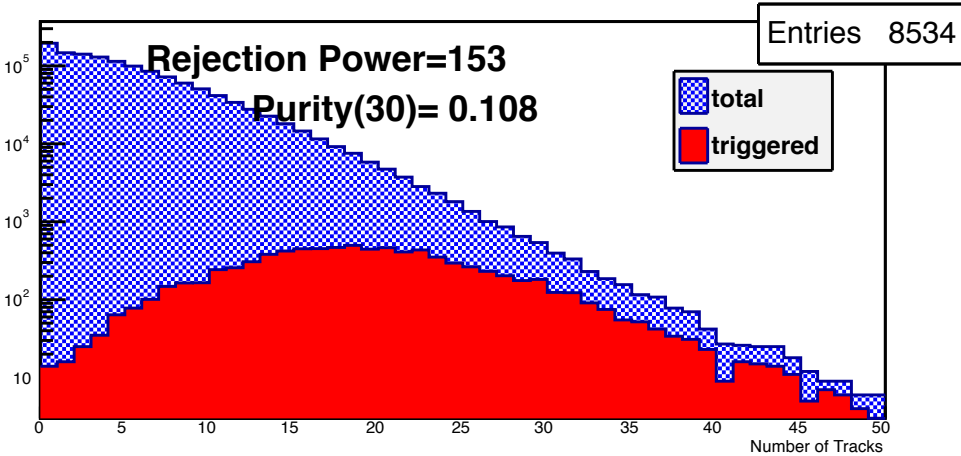
# of track  $\geq 18$

# of online track maximum = 24

# South & North Coincidence

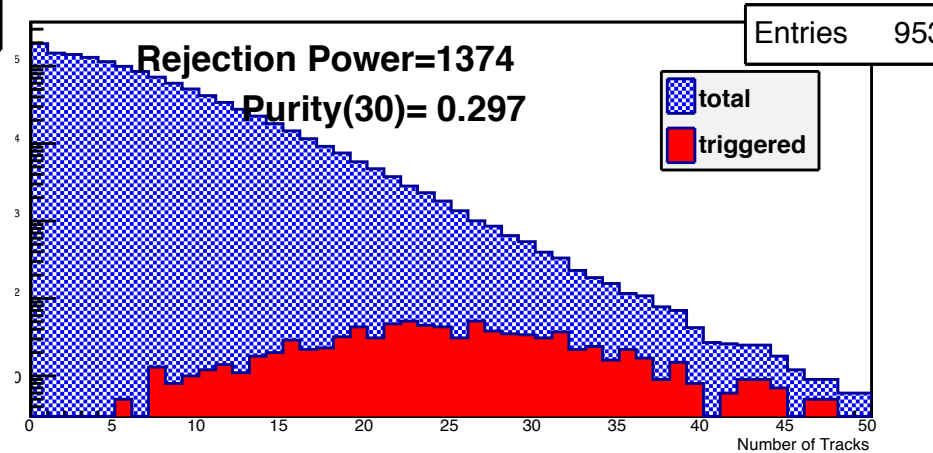
coincidence

Number of Tracks

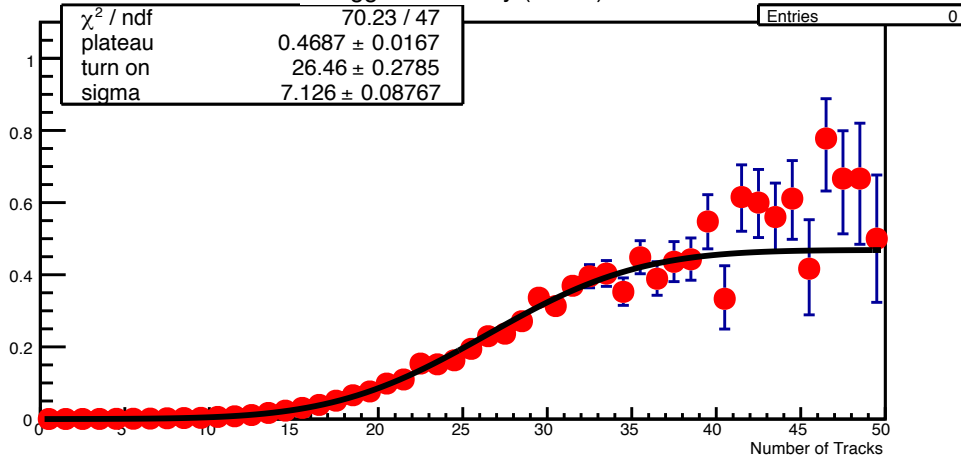


coincidence

Number of Tracks

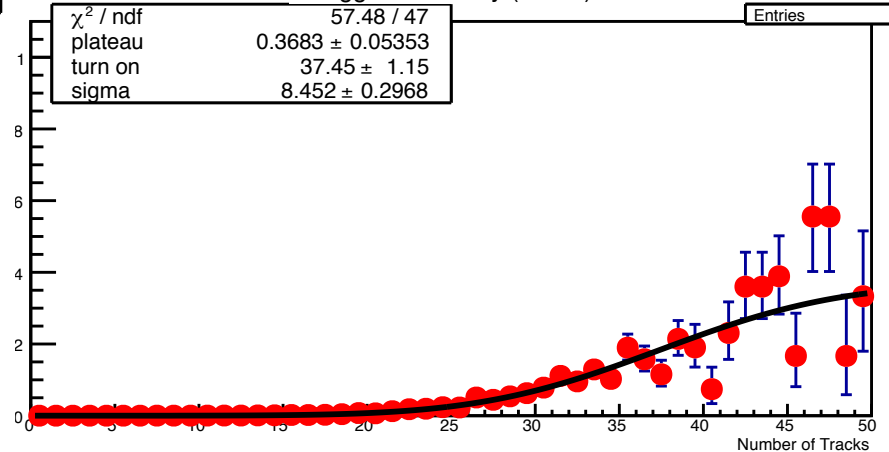


Trigger Efficiency (South)



# tracks  $\geq 12$  /arm

Trigger Efficiency (South)



# tracks  $\geq 16$  /arm

# Trigger Performance Summary

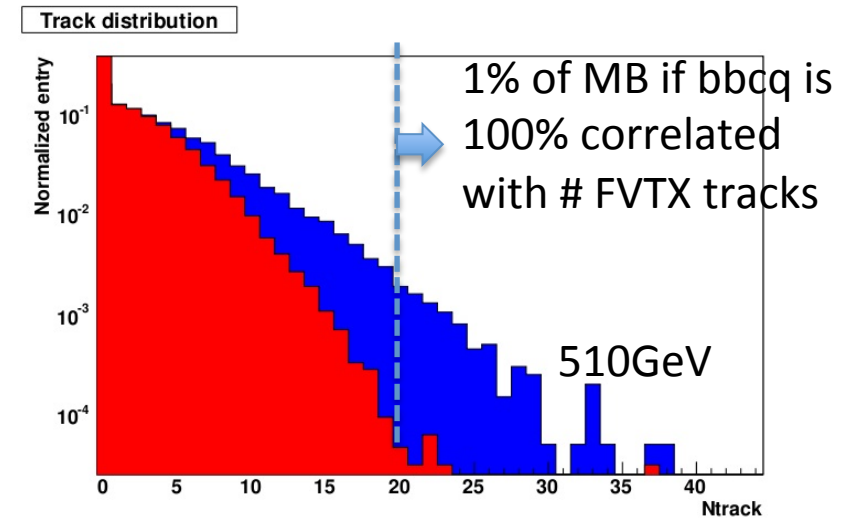
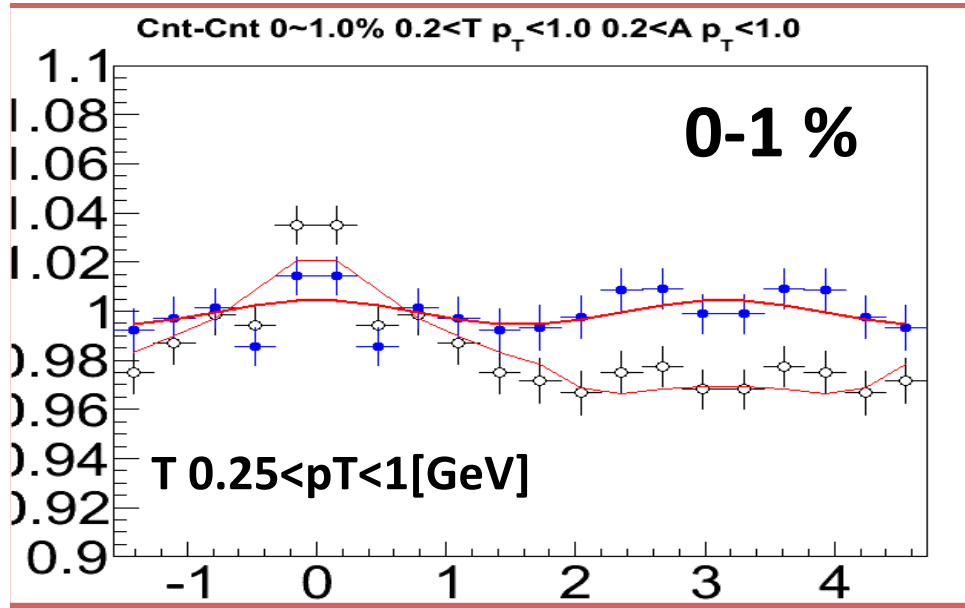
- Asking the trigger mix with BBC narrow VTX, the additional RP  $\sim 5$  is expected.
- The total rejection power of 3000  $\sim$  7000 can be achieved at the cost of efficiency.
- RP $\sim$ 5000 will provides the trigger rate of 1kHz at BBC rate of 5MHz. (May be still need to be prescaled)
- Purity $>30$  is about 0.3.

# Yield Estimate

- FVTX North and South separate trigger bits
- Assumed 500Hz band width
- 500Hz x 30% purity (>30tracks/arm) = 150Hz
- 150Hz x 3600s x 24h x 7days x 7 weeks x 30%  
DAQ time = 150Hz x 1.2M [s] = 190 Mevents

Total 190M events of tracks>30/arm  
(0.04%MB) to be accumulated

# Impact compared to existing study



- MB rate was  $\sim 300\text{Hz}$  in Run13.
- $300\text{Hz} \times 1\% \times 10\text{weeks} \times \text{bbcq efficiency} \sim 5.4\text{M events} \times \text{bbcq efficiency}$
- Bbcq efficiency is the correlation between bbc charge and FVTX multiplicity

# Summary

- We propose to study collective effect in 510GeV pp in Run16.
- Assuming high multiplicity plays essential role of the collective effect regardless of collision energy, 510 GeV has advantage compared to 200GeV.
- The estimated yield of #of tracks>30 is 190Mevents in 7weeks assuming 500Hz bandwidth.
- 190M expected events is at least  $\sim 40$  times more event samples than Hiroshi's Run13 analysis (5.4M)
- We will try to improve the sharpness of the turn on curve by modifying hardware during shutdown.